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ORIGINAL PAPER

Legal and illegal immigrants: an analysis of optimal saving behavior

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Abstract Savings of guest workers as well as of undocumented migrants represent important inflows of foreign exchange for some developing countries. This paper compares the saving behavior of these two types of migrants, assuming that the former are authorized to work abroad for a specific period of time, while the latter can stay until apprehended and deported by the immigration authorities. Due to the risk of deportation, the saving rate of an illegal immigrant is found to be initially above that of a documented migrant. This precautionary saving phenomenon is, however, short-lived. A key finding of the paper is that the total repatriated assets of an illegal migrant are *always lower* than those of a documented worker, provided that their duration of stay abroad is identical. This is because the undocumented migrant's saving rate falls over time as her expected lifetime earnings are adjusted upwards every day that she avoids apprehension.

Keywords Illegal immigration · Uncertainty · Saving behavior

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1 Introduction

The last couple of decades have witnessed a surge in illegal immigration not only to the developed countries but also to the rapidly growing developing economies in East Asia and elsewhere. The International Organization for Migration estimates that

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up to one half of the migrant workforce of the developed countries is unauthorized (IOM 2003).[1] In the USA, 55 % of all Mexican migrants are illegal. For migrants from Central America, the figure is 47 % and for South Americans, 33 % (Center for Immigration Studies 2007). Although illegal immigration is often a source of concern for the receiving economies, it can generate certain benefits for the sending countries, where remittances and repatriated savings of both documented and undocumented immigrants represent important inflows of foreign exchange.[2] Tens of billions of dollars flow every year back to countries like China, India, Mexico, and the Philippines. For less populous labor-exporting countries, the dollar figures are more modest but, in many instances, constitute a large percentage of GDP. According to the World Bank, in El Salvador, Haiti, Jamaica, and Jordan, for example, these inflows amounted to more than 20 % of GDP in 2007, while in Tajikistan, they made up as much as 45.5 %.[3] Remittances and repatriated savings finance not only everyday consumption but also investment in physical and human capital, thus affecting both directly and indirectly the receiving country's development path.[4] It is therefore important to improve our understanding of the determinants of these flows and, hence, the saving behavior of migrants who generate them.

In the present study, I investigate the saving behavior of foreign workers in the context of a dynamic stochastic life-cycle model, emphasizing the distinction between legal and illegal immigrants. The main difference between the two is that the former are allowed to stay in the host country for a prespecified period of time and are obliged to leave when their work permit expires.[5] By contrast, the latter can stay until they are caught by the immigration authorities and subsequently deported. In economies that rely heavily on temporary migration programs, such as the Gulf Cooperation Council states, Hong Kong, South Korea, Taiwan, Brunei, and Israel, deportation is a key instrument of immigration control. It also plays an important role in countries such as Japan and Singapore, where the preservation of the existing ethnic structure of the population is an objective of public policy. An illegal immigrant in such states is therefore subject to uncertainty with respect to the duration of stay, while the legal one is not. I show that this key distinction with respect to the legality of status abroad is responsible for different saving behavior of the two

[1] Each year, the stock of undocumented migrants in the EU is estimated to be growing by 500,000 individuals (IOM 2003). Inflows of similar magnitude are reported for the USA, where the stock of undocumented immigrants was estimated at roughly 10.8 million in the first quarter of 2009 (Center for Immigration Studies 2009).

[2] In 2008, 192 million foreign workers, including those without proper documentation, sent $328 billion from the developed to the developing countries. This represents almost three times the amount of official aid flows from OECD member states (World Bank 2009).

[3] See World Bank, http://blogs.worldbank.org/peoplemove/remittance-flows-to-developing-countries.

[4] See Adams (1991), Durand et al. (1996), Lucas (2005), Massey and Parrado (1998), McCormick and Wahba (2001), and Taylor (1987).

[5] This is the structure of typical guest-worker programs operated in Taiwan, South Korea, and Singapore, with durations of stay limited to 2–5 years. Contract-completion clauses in guest-worker contracts of numerous host economies in Asia allow (in some cases require) employers to withhold a part of a worker's salary until the time of departure. This serves to prevent contract workers from remaining in the host country illegally. The seasonal guest-worker programs in Western Europe and North America typically allow for permits valid for less than a year.

types of migrants. An illegal alien, who is subject to deportation, has an incentive to accumulate "precautionary" savings. While this result is rather intuitive and has already been analyzed in the literature on the optimal saving under uncertainty,[6] the new finding that emerges from my dynamic analysis is that the high saving rate (due to precautionary motive) is short-lived. I show that an undocumented migrant's saving rate falls over time as her expected lifetime earnings are adjusted upwards for as long as she is able to avoid apprehension. Moreover, I find that if a legal guest worker and an illegal immigrant face the same expected duration of stay abroad, the latter always repatriates *less* savings back to the home country, provided that both happen to remain abroad for identical periods of time.

This paper builds on two strands of the literature: the one which examines the optimal consumption under uncertainty, on the one hand, and the optimal saving behavior of migrants, on the other hand. The contributions to the first strand typically seek to estimate the share of aggregate savings attributable to income uncertainty (see, e.g., Caballero (1991) and Skinner (1988)), while the vast literature on migrants' consumption-saving decisions focuses primarily on the differences between permanent and temporary workers or foreigners and natives,[7] or various factors influencing the optimal saving rate of a temporary foreign worker.[8] None of these studies takes into account a migrant's legal status in the host country, although the legality of status is crucial for optimal decision making as it determines whether a migrant operates in an uncertain environment or not. The risk of deportation facing illegal immigrants is modeled explicitly by Friebel and Guriev (2006), but their focus is on how it affects the relationship between human smugglers and their clients, rather than on the saving behavior of the latter.[9] The present study is therefore the first to provide a theoretical analysis of the relationship between a migrant's legal status in the host country and her optimal saving behavior.

The remainder of the paper is organized as follows. In Section 2, I solve the optimization problem of a legal guest worker and an undocumented alien. To highlight the role of deportation risk faced by the latter, I structure the problem so as to set aside other factors that affect a migrant's saving rate, such as international commodity-price differentials, interest differentials, location preferences, entrepreneurial opportunities, etc., which have been treated extensively in the aforementioned literature. In Section 3, I numerically solve for an undocumented migrant's saving rate and compare it with that of a documented guest worker to illustrate the precautionary saving

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[6] See, e.g., Skinner (1988), Toche (2005), Wälde (1999) and Zeldes (1989), to mention just a few.

[7] See, e.g., Djajić (1989).

[8] See Djajic (2010), Djajic and Milbourne (1988), Dustmann (1995, 1997), Kirdar (2010), and Mesnard (2004).

[9] The probability of deportation is also present in the models of Woodland and Yoshida (2006), Djajić (2011) and Auriol and Mesnard (2012). In these papers, however, deportation is a zero-one event happening at the border of the host country. If the migrant is lucky not to get caught at the border, she can work freely in the host country and no longer face any uncertainty. In the present model, the migrant continuously faces the risk of deportation while working in the host country, a feature which fundamentally affects her optimal consumption-saving behavior. Djajić (2013) and Djajić and Vinogradova (2013) consider the possibility of a migrant being subject to deportation while working in the underground economy. In contrast with the present study, however, they treat the problem deterministically.

phenomenon and its relatively short duration. The main objectives of this section are to analyze the evolution of the optimal asset positions of the two types of migrants, examine the conditions under which they repatriate identical amounts of savings, and discuss the implications of host-country migration policies for the inflows of foreign exchange received by the source country. Finally, I conclude the paper in Section 4 by summarizing its main results.

2 The two types of migrants

In a very stylized way, I first define the problem facing a documented guest worker and subsequently that of an undocumented immigrant subject to deportation. In both cases, I assume that the worker migrates at the beginning of the planning horizon, time $t = 0$, and maximizes expected discounted utility of consumption over a lifetime T. The guest worker returns to the home country when her work contract expires, while the undocumented worker remains abroad until she is deported. In both cases, return is the absorbing state in the sense that there are no subsequent migration attempts.

2.1 Legal guest worker

Consider a migrant who is admitted to work abroad as a legal guest worker (G) on a contract that extends over τ units of time. When G signs the contract, she commits herself to the rules of the guest-worker program, does not overstay her visa, and does not return home before time τ (as financial penalties are imposed on her in the case of noncompliance, such as nonpayment of withheld wages, for example). Defining c_t as her instantaneous consumption rate, G's optimization problem may be written as follows:

$$\max_{c_t} \int_0^T u(c_t)e^{-\delta t}\mathrm{d}t,$$

subject to the budget constraint

$$\int_0^\tau (w^* - c_t)e^{-rt}\mathrm{d}t + a_0 + \int_\tau^T (w - c_t)e^{-rt}\mathrm{d}t = 0, \quad (1)$$

where T is the length of the planning horizon, and δ is the constant rate of time preference. In order to focus on the role of legal status of a worker rather than other factors that may influence saving behavior, I assume that the price levels are equal at home and abroad and normalized to unity. The real wage rates abroad and at home, w^* and w , respectively, are assumed constant and $w^* > w$. Equation (1) states that the assets accumulated abroad (discounted at the constant risk-free rate of interest, r, assumed identical in both countries) plus a_0, the initial asset holdings net of migration cost must be equal to the discounted excess of consumption over wage income after return.[10] The utility function is assumed to take the iso-elastic form $u(x) = \frac{x^{1-\theta}}{1-\theta}$, where $\frac{1}{\theta}$ is the elasticity of intertemporal consumption substitution (EICS).

G's optimal consumption path satisfies[11]

$$c_t = c_0 e^{\frac{r-\delta}{\theta} t}, \quad c_0 = \left[w^* \frac{1 - e^{-r\tau}}{r} + a_0 + w \frac{e^{-r\tau} - e^{-rT}}{r} \right] \frac{\frac{r-\delta}{\theta} - r}{e^{\left(\frac{r-\delta}{\theta} - r\right)T} - 1}. \quad (2)$$

This optimal c_t reflects the migrant's desire to enjoy a time path of consumption that is smoother than the time path of earnings, consisting of a higher wage abroad and a relatively lower one after return. Defining a_t as the guest worker's asset position at time t and $g \equiv \frac{r-\delta}{\theta} - r$, we have

$$a_t = a_0 e^{rt} + w^* \frac{e^{rt} - 1}{r} - c_0 \frac{e^{\frac{r-\delta}{\theta} t} - e^{rt}}{g}, \quad a_0 \geqslant 0, \quad t \in [0, \tau_-], \quad (3)$$

$$a_t = a_\tau e^{r(t-\tau)} + w \frac{e^{r(t-\tau)} - 1}{r} - c_\tau \frac{e^{g(t-\tau)} - 1}{g}, \quad a_T = 0, \quad t \in [\tau_+, T]. \quad (4)$$

The amount of assets repatriated at the time of return to the home country is

$$\mathrm{RA}^G \equiv a_\tau = \frac{e^{gT} - e^{g\tau}}{e^{gT} - 1} \left[a_0 e^{r\tau} + w^* \frac{e^{r\tau} - 1}{r} - w \frac{(e^{g\tau} - 1)(1 - e^{r(\tau - T)})}{r(e^{gT} - e^{g\tau})} \right]. \quad (5)$$

Later in the paper RA^{G} will be compared with the magnitude of savings repatriated by an illegal immigrant.[12] The objective is to see how the saving patterns of the two types of migrants differ and, ultimately, to explain any such differences.

2.2 Illegal immigrant

Consider next a migrant who goes abroad as an undocumented alien (U). Assume for simplicity that U and G have the same initial asset holdings net of migration cost and face the same wage rate abroad. The only difference is that due to the illegality of her status, U may be deported back home at any time. The event of deportation is assumed to follow a Poisson process with a constant mean arrival rate λ. If U is caught by the immigration authorities at time t (with probability λdt), she is deported and earns the source-country wage, w, until the end of her planning horizon without subsequent migration attempts. Alternatively, if U is not caught (with probability $1 - \lambda dt$), she earns the higher host-country wage, w^*. U's consumption rate while abroad

[10] I assume that initial assets are large enough to cover migration costs, i.e., $a_0 \geq 0$. I therefore rule out the case of borrowing to finance migration. On this issue, see Djajić and Vinogradova (2013).

[11] The derivations of all the equations are relegated to the Appendix 1.

[12] To make the comparison as clear as possible, I assume that all savings are repatriated at the point of return, regardless of whether the migrant is a contract worker or undocumented alien. Remittances are not modeled explicitly in this paper.

is denoted by c_t^u and the one after deportation, by c_t^d. The Hamilton–Jacobi–Bellman equation for U's optimization problem reads

$$\max_{c_t^u, a_t} \left\{ u\left(c_t^u\right) + \frac{\partial V_t}{\partial a_t}\left(ra_t + w^* - c_t^u\right) \right\} + \lambda\left(V_t^d - V_t\right) - \delta V_t = 0,$$

where the superscript d stands for "deportation," a_t is the state variable of the program, denoting the asset position at time t, and V_t is U's value function.

The following differential equations describe the evolution of U's asset position over time (by convention, a dot over a variable denotes the derivative with respect to time):

$$\dot{a}_t^u = ra_t^u + w^* - c_t^u, \quad a_0^u \geqslant 0, \tag{6}$$

while U is abroad, and

$$\dot{a}_t^u = ra_t^u + w - c_t^d, \quad a_T^u = 0, \tag{7}$$

in the event that U is deported back to the country of origin. The optimal consumption path after deportation can be easily obtained by solving the standard deterministic optimization problem:

$$\max_{c_t^d} \int_{\xi}^{T} u\left(c_t^d\right) e^{-\delta(t-\xi)} dt$$

subject to Eq. (7) and the initial condition given by a_ξ, i.e., the amount of assets accumulated abroad up to time ξ which the migrant brings with her to the source country at the time of deportation. The solution for the optimal consumption growth rate is given by the standard Keynes-Ramsey rule

$$\frac{\dot{c}_t^d}{c_t^d} = \frac{r-\delta}{\theta},$$

which implies the following consumption path:

$$c_t^d = c_\xi^d e^{\frac{r-\delta}{\theta}(t-\xi)},$$

The initial consumption rate, c_ξ^d, is determined by substituting this consumption path into Eq. (7) and solving the resulting differential equation:

$$c_\xi^d = \left[a_\xi + \frac{w}{r}\left(1 - e^{-r(T-\xi)}\right)\right] \frac{g}{e^{g(T-\xi)} - 1}, \tag{8}$$

The stochastic control problem pertaining to the initial phase (i.e., while U is abroad) is solved by differentiating the Hamilton–Jacobi–Bellman equation with respect to c_t^u and a_t, which yields the following differential equation for U's consumption rate (see Appendix 1.2)

$$\frac{\dot{c}_t^u}{c_t^u} = \frac{1}{\theta}\left\{\lambda\left[\left(\frac{c_t^d}{c_t^u}\right)^{-\theta} - 1\right] + r - \delta\right\}, \tag{9}$$

where $c_t^d = c_\xi^d$ if deportation occurs at time $t = \xi$. The intuition behind this equation is easy to grasp. Suppose that there is no uncertainty, i.e., $\lambda = 0$, then the first term in the curly braces vanishes, and the usual deterministic Keynes-Ramsey rule for consumption growth rate applies. It is also clear that the term in the square brackets, which multiplies λ, is unambiguously positive: $(c_t^u/c_t^d)^\theta > 1$, so that the presence of uncertainty results in a higher consumption growth rate relative to the deterministic case. Moreover, the larger the probability of deportation, the faster the consumption growth rate. This higher growth rate can be sustained only with a higher saving rate at the beginning of the planning horizon, implying that uncertainty triggers precautionary saving.[13] As will be shown later, however, the high saving rate (due to the precautionary motive) is short-lived, and the total repatriated assets of U are *lower* than those of G if both end up staying abroad for an identical period of time.

Equations (8)–(9) in combination with the laws of motion of the asset position (6)–(7) form a system which can be solved (not analytically though) for the optimal paths of c_t^u and a_t^u.

3 Migrants' saving behavior

In this section, I numerically solve for U's optimal consumption/saving program. In the next subsection, I compare U's saving rate with that of G and illustrate the precautionary saving phenomenon as well as its relatively short duration. I also analyze the evolution of the optimal asset position of the two types of migrants and explain the key finding of the paper: The total repatriated assets of the guest worker always exceed those of the undocumented worker if both happen to remain in the host country for identical periods of time. In the second subsection, I discuss the conditions under which the two types of migrants repatriate identical amounts of savings.

The numerical simulations are performed for the following values of the model's parameters. The length of a migrant's planning horizon is assumed to be 30 years to roughly correspond to the remaining working life of an Asian migrant from, say, Thailand, whose average age at the time of migration is reported to be in the early thirties.[14] The length of the guest-worker permit is set at 4 years. In fact, conditions of guest-worker programs vary across host countries. The United States Government Accountability Office (2006, p.26) reports that the duration of a permit may vary from 3 months to 5 years in the countries covered by their study. In Japan, Korea, Hong Kong, and Singapore, the permits are typically issued for 2 or 3 years (see, e.g., OECD (2002) and Spencer (1992)). OECD (2002) also provides an extensive discussion of immigration policies in Asian countries, including deportation measures aimed at illegal immigrants. For example, in the case of Malaysia, the stock of undocumented Indonesian migrants is estimated to be 450,000, and 10,000 are deported every month (OECD (2002), p.254). These figures imply a deportation rate of 0.26 per year. In Japan, the stock of illegal aliens was estimated at 193,745 with 33,192 deportations in 2005 (Vogt 2007), implying a deportation rate of roughly

[13] Toche (2005) obtains a similar result in the context of a model with a random employment status; see also Wälde (1999).

[14] See Jones and Pardthaisong (1999), Sobieszczyk (2000). Amuedo-Dorantes et al. (2005) report that the average age of Mexican migrants to the USA in the Mexican Migration Project (MMP93) was 33 years, and their average length of stay was close to 3 years.

0.17. In line with these figures, the parameter λ is calibrated at $1/4$ per year, implying that U's expected stay abroad is equal to 4 years (by the property of the Poisson process). The assumption that U's expected duration of stay abroad is equal to the length of the guest-worker permit will allow us to make meaningful comparisons of their saving behavior: the behavior of G can be interpreted as the certainty-equivalent behavior of U.

An important parameter of the model is θ, which is the inverse of the elasticity of intertemporal consumption substitution (hereafter, EICS). Although there is no unanimous view in the literature on the magnitude of this parameter, many empirical studies of EICS conclude that the relevant values lie below 2, which corresponds to θ above 0.5.[15] I calibrate θ at 0.75 for the benchmark case and check the sensitivity of the results to changes in this parameter. It turns out that even for a wide range of calibrations, from $\theta = 0.25$ to $\theta = 5$, the qualitative conclusions remain unaffected, and even the quantitative results are not significantly affected, as we shall see below.

The relative real wage differential is set at 2, which roughly corresponds to the case of Thai migrants in South Korea. The real risk-free interest rate, r, is 3 % per year. The rate of time preference, δ, for simplicity, is set equal to r.[16] The parameter values used in the benchmark simulation are summarized in Table 1.

3.1 Comparing saving rates

Saving dynamics are illustrated in Fig. 1, with the benchmark case shown by the bold lines. U's time profile of saving (bold dashed line) is drawn under the assumption that deportation occurs precisely at $t = 4$ (corresponding to the average waiting time until deportation), so that U and G leave the host country simultaneously.

The precautionary saving phenomenon can be clearly recognized: U's saving rate exceeds that of G (shown by the bold solid line) during the first year abroad. Note, however, that U's saving rate declines monotonically until the time of deportation and by then falls well below G's rate, reflecting the higher consumption growth rate under uncertainty derived in Eq. (9).

What accounts for this lower pace of wealth accumulation in spite of the positive effect of deportation risk on the saving rate in the early phase of U's planning horizon? The apparent paradox can be easily explained. As the time spent abroad by an illegal immigrant increases without detection, her total expected lifetime income continuously grows. She therefore has a weaker and weaker incentive to save, so that her saving rate declines monotonically to fall short of G's rate at the point of return.

[15] To my knowledge, there are no empirical studies which attempt to estimate θ for illegal (or even legal) migrants. Vissing-Jørgensen (2002) estimates EICS for stock- and bondholders, distinguishing among three wealth groups, as well as for non-stockholders. Her estimates range from 0.29 for stockholders to 1.38 for bondholders with higher estimates for top wealth layer households and close to zero estimates for non-stockholders. See also Epstein and Zin (1991), Hansen and Singleton (1982), and Keane and Wolpin (2001). I rely on these estimates for calibrating θ in my quantitative analysis.

[16] With $\delta = r$ the time path of a guest worker's consumption is flat at the level c_0, while that of the undocumented migrant is upward sloping when she is located abroad and flat after deportation. When $\delta < r$ ($\delta > r$), the time paths of consumption of both G and U rotate counterclockwise (clockwise), which results in a larger (smaller) amount of savings repatriated to the source country.

Table 1 Benchmark calibration

Planning horizon, years	T	30
Guest worker permit, years	τ	4
Relative real wages	w^*/w	2
Risk-free interest rate	r	0.03
Rate of time preference	δ	0.03
Poisson deportation rate	λ	$1/4$
Elasticity of marginal utility	θ	0.75
Initial assets net of migration cost	a_0	0

In fact, just prior to being apprehended and deported, U still *expects* to remain in the host country for another $1/\lambda$ years.

As a comparative statics exercise, I use thin lines in Fig. 1 to show the migrants' saving paths when the deportation policy is less stringent, with $\lambda = 0.1$, akin to what we observe, for example, in the EU. To have a meaningful comparison, the assumed duration of G's stay abroad, τ, is set at $1/\lambda = 10$. The corresponding saving schedules follow exactly the same pattern as in the benchmark case, except for the downward displacement. The saving rate abroad is reduced for both U and G as their expected duration of stay (and therefore their lifetime earnings) is increased. Also note that U's dissaving rate after return is lower than that of G since U has not

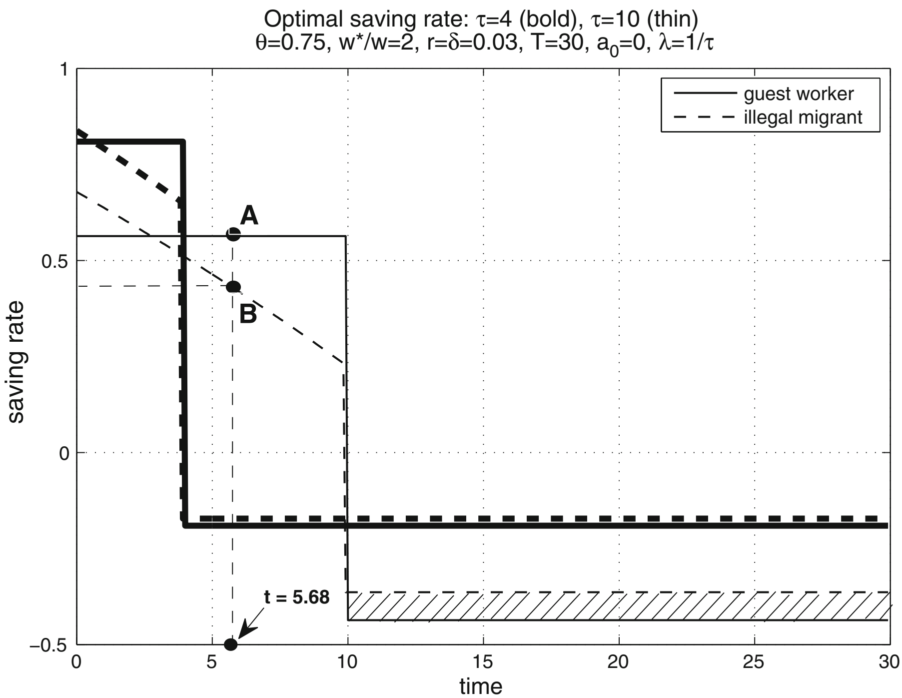


Fig. 1 Saving rates, $\tau = 4$ (*thick lines*), $\tau = 10$ (*thin lines*)

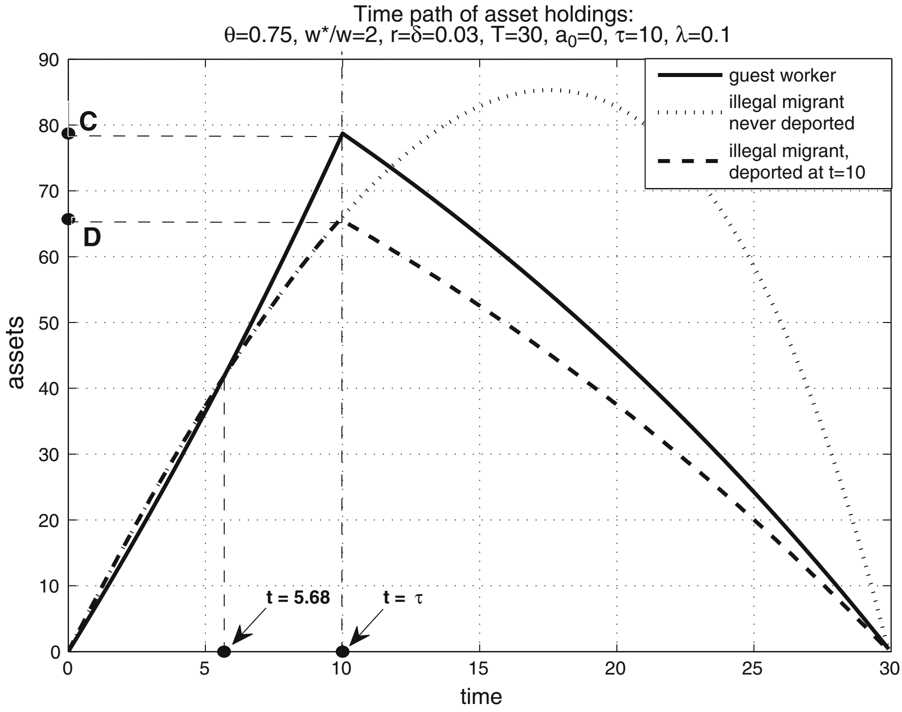


Fig. 2 Total assets

accumulated as much wealth abroad as G has. The discrepancy is more pronounced for lower Poisson deportation rates.

Differences in the saving rates of U and G translate into different time paths of their asset positions. Figure 2 shows the evolution of asset holdings of U (dashed line) and of G (solid line) for the case of $\tau = 10$ and $\lambda = 0.1$. The precautionary saving phenomenon can be recognized again by noting that the undocumented migrant's asset position exceeds that of the guest worker until approximately $t = 5.68$. Recall that the growth rate of a migrant's asset position is just the interest earned on the stock of assets plus the saving rate. At time $t = 5.68$, the asset positions of G and U are equalized, but the saving rate of U is lower than that of G by the amount AB in Fig. 1, so that the growth rate of U's asset position (the slope of the dashed line in Fig. 2) is lower than the growth rate of G's asset position (the slope of the solid line).

By the time of deportation at $t = 10$, U's asset holdings are 16.55 % lower than those of G. The difference in repatriated wealth, shown by the distance CD, corresponds to the shaded surface in Fig. 1. Should U be lucky enough to never get deported, her stock of assets would evolve along the dotted line.[17]

[17]Note that the longer U manages to remain abroad, the shorter is the second, source-country phase of her planning horizon. As the duration of the first phase expands and that of the second phase contracts, with U successfully avoiding apprehension, it eventually becomes optimal to repatriate a smaller stock of savings by actually dissaving while abroad.

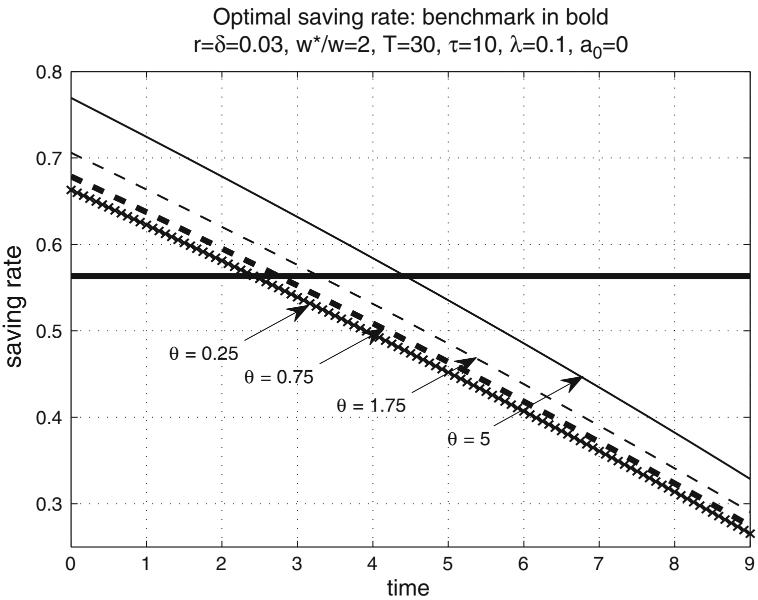


Fig. 3 Saving rates and EICS: benchmark $\theta = 0.75$ (*bold lines*), $\theta = 0.25$ (*bottom lines*), $\theta = 1.75$ (*thin dashed lines*), $\theta = 5$ (*thin solid lines*)

The saving rates, and consequently the magnitude of accumulated assets, depend on the chosen value of the elasticity of intertemporal consumption substitution (EICS). In the next figure, I show, however, that EICS plays a minor role, in the sense that none of the qualitative results concerning the saving rates are affected by a large change in EICS. Moreover, even the quantitative results are not significantly affected. Figure 3 shows the saving dynamics of U and G for the benchmark case $\theta = 0.75$ (EICS $= 1/\theta = 1.33$) with bold lines, while the thin lines show U's saving rate for $\theta = 0.25$ (bottom line), $\theta = 1.75$ (thin dashed line), and $\theta = 5$ (thin solid line).

The simplifying assumption that $r = \delta$ implies that θ does not affect the optimal consumption path of G (see Eq. (2)), but it does affect the optimal consumption path of U (recall Eq. (9)). Figure 3 demonstrates that the difference between U's saving rate under alternative calibrations of θ is quite small with a slightly higher saving rate associated with a greater degree of concavity of the utility function. For instance, at the moment just before deportation ($t = 10$), U saves 11.61 % of her income with $\theta = 0.75$ and 12.35 % of her income with $\theta = 1.75$. The repatriated assets are only 4.55 % higher with a higher θ and are still 12.74 % below those of G.

The assumption that deportation of U occurs precisely on the date that coincides with the expiration of the work permit for G is a useful expositional tool that enables us to highlight the differences between saving behavior of the two types of migrants under specific conditions. In reality, deportation may occur at any time, and in addition, there is no reason to expect that a host country's choice of τ is identical to its choice of $1/\lambda$. In the next subsection, I consider the general case where the focus of the analysis is on the determinants of the *aggregate* flows of repatriated assets that a source country can expect to receive for any given stock of migrants employed abroad.

3.2 Comparing repatriated assets

My analysis of the optimizing behavior of U and G naturally raises some important questions that have not been addressed in the theoretical literature: Does a larger proportion of documented to undocumented migrants contribute to a larger or smaller inflow of repatriated savings per worker? How is this relationship affected by the host country's deportation policy and its restrictions on the maximum duration of a guest-worker contract? In the analysis that follows, I develop a basis for addressing these questions by first comparing the magnitude of repatriated assets of a guest worker, RA^{G}, with the *expected* repatriated assets of an illegal immigrant, $\mathrm{ERA}^{\mathrm{U}}$.[18]

The amount that a guest worker repatriates at the point of return is given by Eq. (5). In the case of an undocumented migrant, the expected amount of repatriated assets is defined as $\mathrm{ERA}^{\mathrm{U}} = \int_0^T a_s f_s ds$, where $f_s = \frac{\lambda e^{-\lambda s}}{1-e^{-\lambda T}}$ is the density of a truncated-exponentially distributed random variable.[19] The graphical illustration of RA^{G} and $\mathrm{ERA}^{\mathrm{U}}$ is provided in Fig. 4, where the horizontal axes are the expected duration of stay abroad, $1/\lambda$, for U and the duration of the permit, τ, for G. The solid line shows RA^{G} as a function of τ , while the dashed line shows $\mathrm{ERA}^{\mathrm{U}}$ as a function of λ. That is, for each arrival rate λ (or, equivalently, expected duration of stay abroad, which is shown on the horizontal axes), I calculate the optimal asset position held at each point in time, conditional on survival until that time. Then, given the distribution of actual duration of residence, I calculate expected repatriated assets as a weighted sum (or in continuous time, an integral) of assets at each point in time between 0 and T, where the weights are given by the chances of "surviving" until that time. For instance, point C in Fig. 4 corresponds to point C in Fig. 2. But the value of assets corresponding to point F in Fig. 4 does not correspond to point D in Fig. 2. The value at F is the *average* flow of repatriated assets per deported undocumented worker when $\lambda = 0.1$. It is lower than that marked by D in Fig. 2, which is the amount of assets that a deportee repatriates under the assumption that $\lambda = 0.1$ *and* that deportation occurs precisely at $t = 1/\lambda$.

Considering realistic durations of stay abroad, Fig. 4 demonstrates that, on average, the savings brought back by a deported undocumented worker are always lower than those of a documented one if the deportation policy is such that $\lambda = 1/\tau$.[20]

[18] Since G does not face any uncertainty with respect to her duration of stay abroad, her actual and expected RA are identical. Due to the risk of deportation, however, those of U are not.

[19] Given that the event of deportation follows the Poisson process, the waiting time until deportation is an exponentially distributed random variable. The truncation is necessary since the migrant's planning horizon is finite (equal to T). With an infinite horizon, the density is just the numerator of f_s.

[20] For very long expected durations of stay abroad ($\lambda \to 1/T$) and the corresponding lengths of the permit ($\tau \to T$), G behaves as a permanent migrant with her repatriated savings approaching zero, while U's expected RA are positive due to the presence of deportation risk. These values of τ are not empirically relevant, and so they do not merit further discussion in the paper.

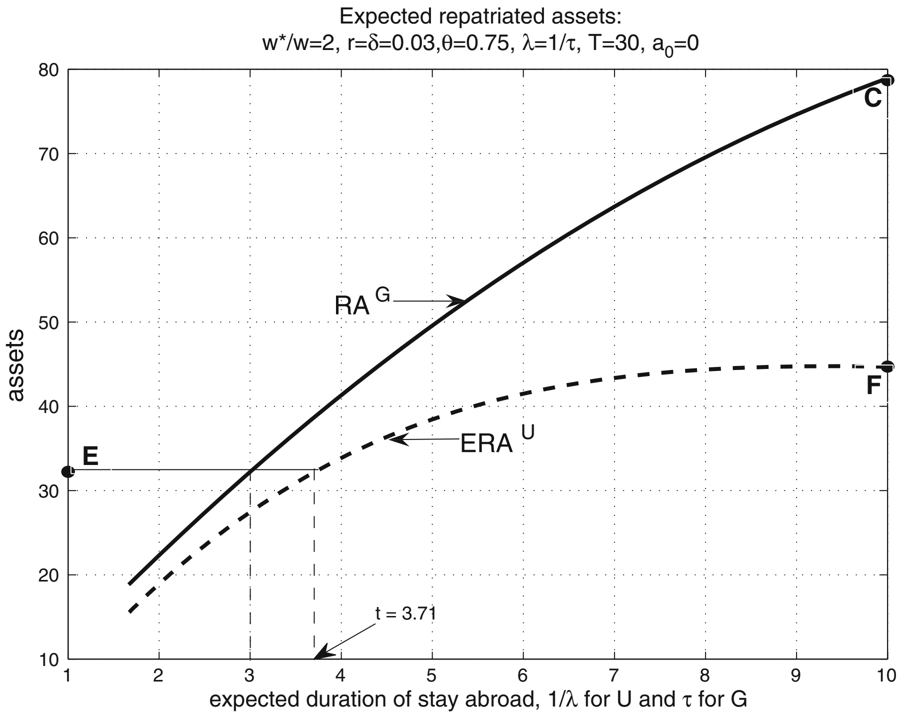


Fig. 4 Expected repatriated assets

For the benchmark values of the parameters, an average undocumented migrant repatriates 14.83 % less than a documented worker when the expected duration of stay abroad for both types of workers amounts to 3 years. This percentage increases monotonically with the expected duration of stay, reaching 43.37 % when the duration is 10 years. Thus, an average undocumented deportee will bring back the same amount of savings as a documented guest worker only if $\lambda < 1/\tau$. In particular, if τ is set at 3 years, as is often the case, for example, in South Korea, Singapore, and Taiwan, an undocumented immigrant earning the same wage as a documented guest worker will repatriate an identical amount of savings (shown by point E in Fig. 4) only if her expected duration of stay abroad is 3.71 years.

This analysis of the links between immigration policies of a host country and the migrants' saving behavior can be extended further to identify combinations of the maximum contract duration (τ) and the deportation rate (λ) such that the two types of migrants bring back identical amounts of expected repatriated assets. These combinations are traced by the bold curve in Fig. 5, showing the values of τ (on the vertical axis) and $1/\lambda$ (on the horizontal axis) such that $\mathrm{RA}^{\mathrm{G}} = \mathrm{ERA}^{\mathrm{U}}$.

Anywhere above (below) the curve, G repatriates more (less) assets than U does. Note that the $\mathrm{RA}^{\mathrm{G}} = \mathrm{ERA}^{\mathrm{U}}$ schedule lies to the right of the 45° line, confirming what has been established in Fig. 4: For any expected duration of an illegal stay abroad,

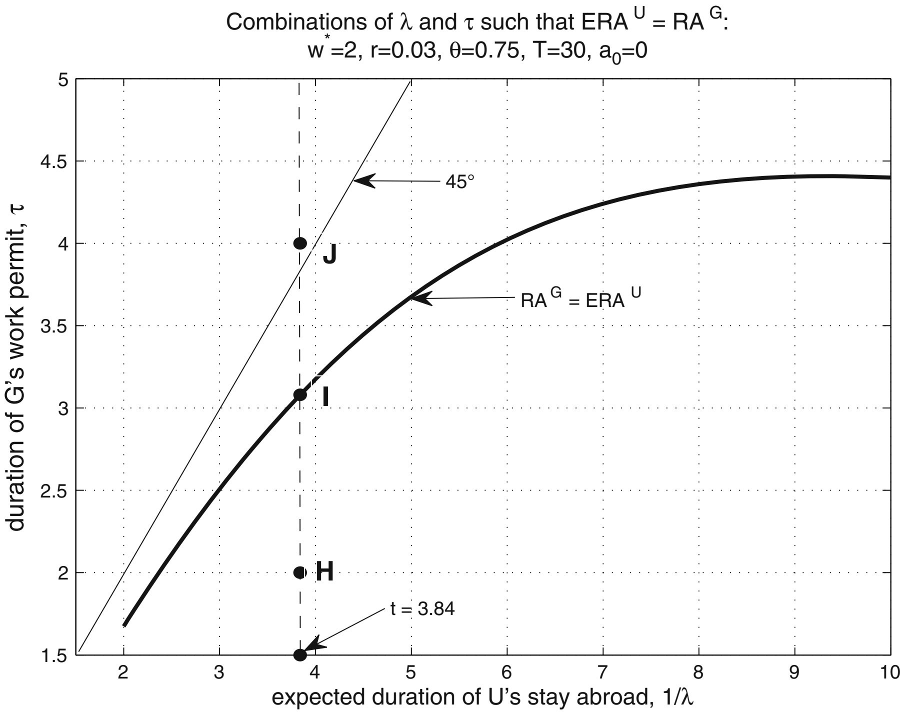


Fig. 5 Combinations of τ and λ such that $\mathrm{ERA}^{\mathrm{U}} = \mathrm{RA}^{\mathrm{G}}$

which is equal to (or less than) the maximum duration of a guest-worker permit, U repatriates less assets, on average, than G does.

For realistic expected durations of undocumented stay, which are to the left of the peak of the curve, one can identify which migrant type contributes more to the aggregate inflow of foreign exchange from a given host country. For instance, undocumented Indonesian migrants in Malaysia face a deportation rate of 0.26, or their expected length of stay is 3.84 years. In that context, if an Indonesian guest worker is allowed to work in Malaysia for only 2 years (point *H* in Fig. 5), he will then repatriate less assets than an undocumented worker. If, instead, G is allowed to work for a little more than 3 years (point *I*), both U and G will repatriate almost identical amounts. By contrast, if G's contract is for 4 years (point J), his repatriated savings will exceed those of U. Accordingly, if Malaysia's immigration policies correspond to point *H* (point *J*), the model predicts that an increase in the proportion of undocumented to documented Indonesian migrants will result in an increase (decrease) in Indonesia's inflow of repatriated savings per migrant worker.

As a final point, note that an increase in the foreign wage rate, w^*, shifts the $\mathrm{RA}^{\mathrm{G}} = \mathrm{ERA}^{\mathrm{U}}$ schedule up. Thus, the greater the international wage differential, the greater the value of $\mathrm{ERA}^{\mathrm{U}}$ relative to RA^{G}. Figure 6 shows the $\mathrm{RA}^{\mathrm{G}} = \mathrm{ERA}^{\mathrm{U}}$

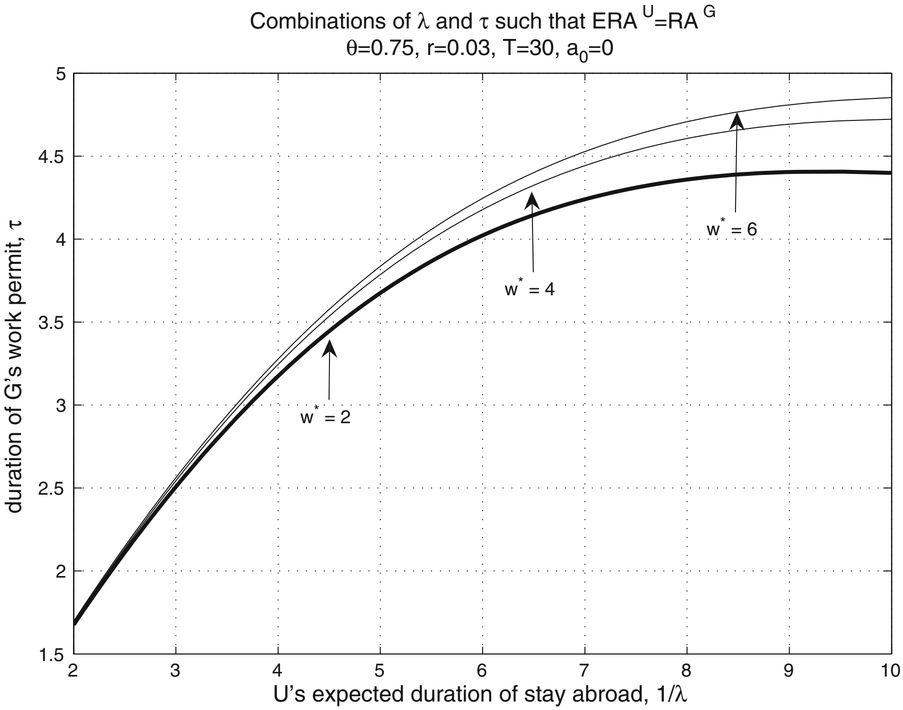


Fig. 6 Effect of change in foreign wage

schedule for $w^* = 2$ (benchmark case), $w^* = 4$, and $w^* = 6$, with the source-country wage, w, normalized to unity. The main message conveyed by the figure is that changes in w^* do not have a large quantitative impact on RA^{G} relative to $\mathrm{ERA}^{\mathrm{U}}$ for empirically relevant values of the immigration policy parameters τ and λ. This is particularly true in the East Asian context where deportation measures are quite strict, and guest-worker contracts are limited in duration to just a few years.

3.3 Implications for policy

An important policy implication of the preceding analysis is that irregular migration is less desirable than documented, guest-worker migration for more than just the obvious reasons. To start with the obvious, it is widely recognized by the source countries that lack of legal status often exposes their citizens to various forms of human rights abuses abroad. It may also result in their citizens being underpaid in precarious and unpleasant jobs that are typically available in the underground economy. The cost of migration, as well, tends to be relatively higher when it is clandestine, imposing a heavy financial burden on undocumented migrants and their families. All these factors have a negative impact on the level of welfare of the migrants and result in reduced flows of savings back to the source country. Yet at the micro level, these flows are not just a crucial source of income for significant proportions of households, but they are often a key element of their livelihood strategies. At the macro level, too, as noted in Section 1 , the savings of migrant workers play a very important role in numerous developing countries.

The present study shows that undocumented migration to host countries with active deportation measures is even less desirable than currently understood. Less desirable, that is, from the point of view of the migrants and their countries of origin. There are two important new elements that emerge from our model. First, the risk of deportation distorts an undocumented immigrant's consumption path, making it less efficient in generating discounted lifetime utility than what would be the case in the absence of deportation measures. Second, in spite of the fact that risk of deportation triggers precautionary savings, an undocumented migrant facing the prospect of deportation does not, other things being equal, repatriate a larger stock of accumulated assets than a documented worker does. The preceding analysis demonstrates that *documented* migrants repatriate relatively larger amounts, assuming that they receive the same wage and have the same expected duration of stay abroad as do undocumented workers. Thus, the flow of repatriated savings, for any given stock of migrants abroad, can be expected to increase if the status of migrants changes from undocumented to documented, assuming their average duration of stay remains the same. The present study therefore offers two fresh new arguments in support of source-country efforts to establish orderly guest-worker programs with host countries—programs that meet the labor shortages of the latter, while taking illegality and risk of deportation out of the optimization problem of the workers.

4 Conclusion

The present study is the first to explore the implications of a migrant's legal status for the time path of her propensity to save and for the amount of assets she repatriates to the country of origin. The analysis employs a dynamic stochastic optimization framework in which undocumented immigrants face deportation (arriving with a Poisson rate), while documented migrants work on a fixed-term contract. The findings contribute to our understanding on how the distinction between "legal" and "illegal" status of migrant workers affects their behavior both at the micro level (as it relates to the optimal consumption and saving) and the macro level (in influencing the average flow of savings per worker back to the source country). Specifically, I show that if the host country's deportation policies are such that an illegal alien faces an expected duration of stay abroad equal to the length of the work permit of a documented guest worker, the former saves at a *higher* rate than the latter does in the initial phase of their foreign stay. However, should both of them happen to remain abroad for an identical period of time, the former repatriates *less* savings back to the source country than the latter does. While this result may seem counterintuitive at first, it stems from the fact that an undocumented worker's saving rate declines continuously over time, as long as she does not get deported, because her expected lifetime earnings are continuously adjusted upwards. It quickly falls below the saving rate of a documented migrant after an initial phase of intensive precautionary saving. The model assumes that the Poisson deportation rate is constant. If it were to decrease with the duration of stay abroad (e.g., as a result of learning how to avoid detection), this tendency for the saving rate of an undocumented migrant to decline over time would be even more pronounced.

When comparing *expected* repatriated assets of the two types of migrants, I show that undocumented workers always bring back less savings, on average, than documented workers do, assuming the expected duration of an illegal stay is equal to the duration of the work permit. For instance, an average undocumented migrant repatriates 14.83 % less than a documented worker when the expected duration of stay abroad for both types of workers amounts to 3 years. This percentage increases monotonically with the expected duration of stay reaching 43.37 % when the duration is 10 years. I also show the combinations of the expected duration of an undocumented stay and the length of a guest-worker contract such that the two types of migrants repatriate, on average, identical amounts of savings. These two immigration policy variables of the host country are shown to have an important influence in determining which type of migration—documented or undocumented—generates a larger per-migrant inflow of foreign exchange into the source country.

At a more general level, the model helps explain the apparently paradoxical empirical finding that, in spite of the precautionary saving motive, people with relatively more risky incomes save less than people with relatively less risky incomes. As noted by Skinner (1988, p. 3): "Empirical comparisons of savings rates among occupations with different income uncertainty provide little support for the view that precautionary savings are important. Data from the 1972–73 Consumer Expenditure Survey imply that self-employed and sales persons, those typically thought to have the most risky income, actually save *less* than other groups..." The principal finding of the present paper that the precautionary saving phenomenon is short-lived helps explain the paradox and shows that Skinner's observations are perfectly consistent with optimizing behavior.

Appendix 1: Solution to a guest worker's and an illegal worker's optimization programs

1.1 Legal guest worker

The objective is to maximize

$$V^G = \int_0^T u(c_t)e^{-\delta t}\mathrm{d}t,$$

subject to the budget constraint

$$\int_0^\tau (w^* - c_t)e^{-rt}\mathrm{d}t + a_0 + \int_\tau^T (w - c_t)e^{-rt}\mathrm{d}t = 0. \tag{10}$$

The Lagrangian function is given by

$$L=\int_0^T u(c_t)e^{-\delta t}\mathrm{d}t+\mu\left[\int_0^{\tau}(w^*-c_t)e^{-rt}\mathrm{d}t+a_0+\int_{\tau}^T(w-c_t)e^{-rt}\mathrm{d}t\right]$$

and the first-order condition with respect to consumption choice

$$\frac{\partial L}{\partial c_t}=u'(c_t)e^{-\delta t}-\mu e^{-rt}=0. \tag{11}$$

Equation (11) implies that consumption rate is equal to $c_t=c_0e^{\frac{r-\delta}{\theta}t}$, with $c_0=\mu^{-1/\theta}$ and where we used the iso-elastic utility specification $u(x)=\frac{x^{1-\theta}}{1-\theta}$. Using this in the budget constraint (10), we obtain

$$\int_0^{\tau}\left(w^*-c_0e^{\frac{r-\delta}{\theta}t}\right)e^{-rt}\mathrm{d}t+a_0+\int_{\tau}^T\left(w-c_0e^{\frac{r-\delta}{\theta}t}\right)e^{-rt}\mathrm{d}t=0.$$

Solving for c_0, we obtain Eq. (2) in the text.

1.2 Illegal immigrant

The problem of a migrant facing a risk of deportation is a stochastic optimal control problem which can be addressed by writing the Hamilton–Jacobi–Bellman equation:

$$\max\quad\left\{u\left(c_t^u\right)+\frac{\partial V_t}{\partial a_t}\left(ra_t+w^*-c_t^u\right)\right\}+\lambda\left(V_t^d-V_t\right)-\delta V_t=0, \tag{12}$$

where the superscript d stands for "deportation," and V_t is U's value function. The first-order conditions with respect to c_t^u and a_t yield

$$u'\left(c_t^u\right)-\frac{\partial V_t}{\partial a_t}=0, \tag{13}$$

$$\frac{\partial^2 V_t}{\partial a_t^2}\dot{a}_t+r\frac{\partial V_t}{\partial a_t}+\lambda\left(\frac{\partial V_t^d}{\partial a_t}-\frac{\partial V_t}{\partial a_t}\right)-\delta\frac{\partial V_t}{\partial a_t}=0. \tag{14}$$

Differentiating (13) with respect to time and using the result in Eq. (14) yields

$$\frac{u''(c_t^u)}{u'(c_t^u)}\dot{c}_t^u+r+\lambda\left(\frac{u'\left(c_t^d\right)}{u'(c_t^u)}-1\right)-\delta=0.$$

After rearranging terms and using $u'(c_t^i)=(c_t^i)^{-\theta}$ ($i=d,u$) we obtain

$$\frac{\dot{c}_t^u}{c_t^u}=\frac{1}{\theta}\left\{\lambda\left[\left(\frac{c_t^d}{c_t^u}\right)^{-\theta}-1\right]+r-\delta\right\}. \tag{15}$$

Note that the term in the square brackets is unambiguously positive as the consumption rate in deportation, c_t^d, is always smaller than c_t^u, otherwise migration would not have taken place. Thus, the ratio c_t^d/c_t^u raised to a negative power is always greater than unity.

It is obvious from the above equation that the solution depends on the migrant's consumption in "deportation," c_t^d. But c_t^d can be easily obtained by solving the deterministic optimization problem of an individual who is deported at an arbitrary time, say $\xi \in [0, T]$. His objective is to maximize

$$\int_{\xi}^{T} u\left(c_t^d\right) e^{-\delta(t-\xi)} \mathrm{d}t$$

subject to

$$\dot{a}_t = ra_t + w - c_t^d, \tag{16}$$

the terminal condition $a_T = 0$ and the initial condition given by a_ξ, i.e., the amount of assets accumulated abroad up to time ξ which the migrant brings with him to the source country at the time of deportation.

The present value Hamiltonian is

$$H = u\left(c_t^d\right) e^{-\delta(t-\xi)} + \nu_t \left[ra_t + w - c_t^d\right],$$

where ν_t is the co-state variable, and the first-order conditions are

$$\frac{\partial H}{\partial c_t^d} = 0 => \quad u'\left(c_t^d\right) e^{-\delta(t-\xi)} = \nu_t \tag{17}$$

$$\frac{\partial H}{\partial a_t} = -\dot{\nu}_t => \quad r\nu_t = -\dot{\nu}_t \tag{18}$$

Taking the time derivative of Eq. (17) and using the result in Eq. (18), we obtain the usual Ramsey type condition for consumption growth rate

$$\frac{\dot{c}_t^d}{c_t^d} = \frac{r-\delta}{\theta}, \quad t \in [\xi_+, T].$$

This equation implies the following consumption path

$$c_t^d = c_\xi^d e^{\frac{r-\delta}{\theta}(t-\xi)},$$

where c_ξ^d is determined by solving the differential equation for asset accumulation (16):

$$c_\xi^d = \left[a_\xi + \frac{w}{r}\left(1 - e^{-r(T-\xi)}\right)\right] \frac{g}{e^{g(T-\xi)} - 1}, \tag{19}$$

Now, Eq. (19) can be substituted in Eq. (15) to yield the law of motion for the illegal immigrant's consumption. The next step is to solve the system of two differential equations, one for consumption and the other for assets accumulation, which is done numerically.

Appendix 2: Robustness checks

This Appendix examines the sensitivity of the results to various model specifications.

2.1 Unequal wages for legal and illegal workers

I denote the foreign legal wage of the guest worker by w^{*G} and the underground wage of the undocumented worker by w^{*U} and show their combinations such that repatriated assets of the two types of migrants are identical. Figure 7 shows two upward sloping schedules, one for the benchmark case $\tau = 4$ and $\lambda = 0.25$ (solid line) and the other for $\tau = 10$ and $\lambda = 0.1$ (dashed line). Note that the slopes of both schedules are, as expected, less than unity. That is, for the expected repatriated assets to be identical for the two types of migrants, the wage of the legal worker should be lower than the underground wage. The larger the host-country underground wage, the wider the discrepancy should be.

For example, in the benchmark case (see solid line), if $w^{*U} = 2$, then w^{*G} must be around 1.8, or 10 % lower, but if $w^{*U} = 10$, then w^{*G} must be around 8.64, or 13.6 % lower, in order to keep $\mathrm{RA^G} = \mathrm{ERA^U}$. Anywhere above (below) the $\mathrm{RA^G} = \mathrm{ERA^U}$ schedule, a guest worker repatriates more (less) than an undocumented worker. In addition, the longer the expected duration of stay abroad, the smaller should the legal

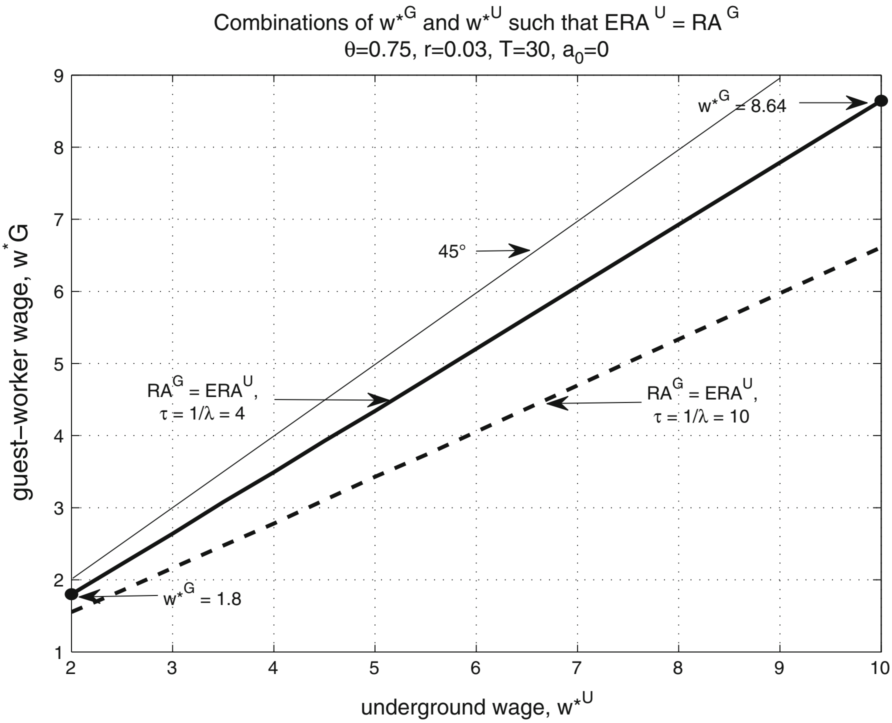


Fig. 7 Combinations of w^{*G} and w^{*U} such that $\mathrm{ERA^U} = \mathrm{RA^G}$

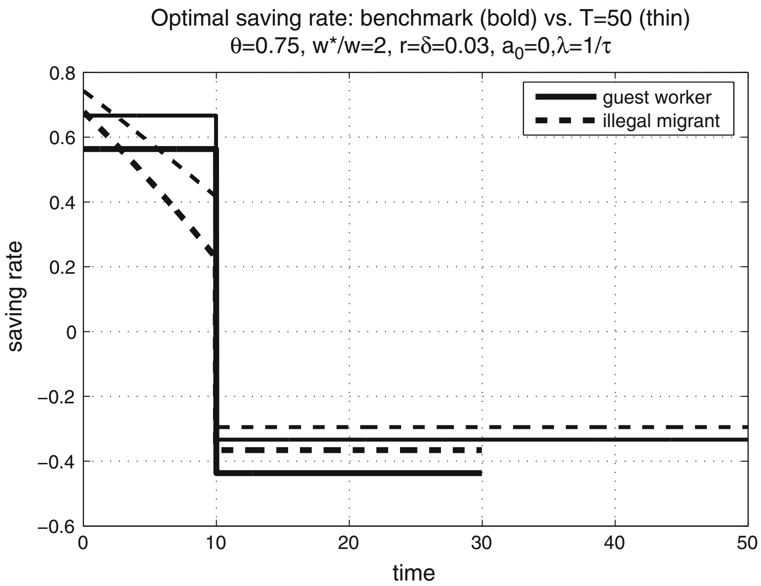


Fig. 8 Longer planning horizon, T

wage be in order to keep $\mathrm{RA^G} = \mathrm{ERA^U}$. This is illustrated by the dashed schedule (longer τ) which lies below the solid schedule (short τ). The intuition is straightforward: When the expected duration of stay abroad is relatively long, the second phase of the planning horizon, i.e., back home, becomes relatively short. An illegal migrant will accumulate smaller savings than in the case of a short expected duration. Therefore, the legal wage must be even smaller for the repatriated assets to remain equalized.

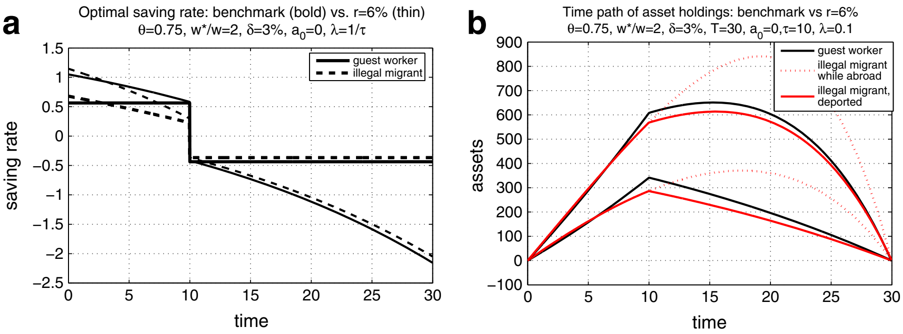
2.2 Planning horizon

The effect of extending migrants' planning horizon from $T = 30$ years to $T = 50$ years, while keeping the other parameters at their benchmark values and $\lambda = 0.1$, is shown in Fig. 8.

A longer planning horizon obviously calls for an increase in the saving rate while abroad for both types of migrants (see thin lines) since the savings now need to finance home-country consumption over a longer period of time. The precautionary saving motive during an initial phase of foreign stay in the case of the illegal migrant is still present. As in the benchmark, her saving rate falls over time and by $t = 1/\lambda = 10$ is way below the legal guest worker's rate.

2.3 Interest rate

Figures 9 and 10 show what happens to the time paths of the saving rate and the asset position when the interest earned on savings differs from the migrants' rate



Saving rate. Time path of assets.

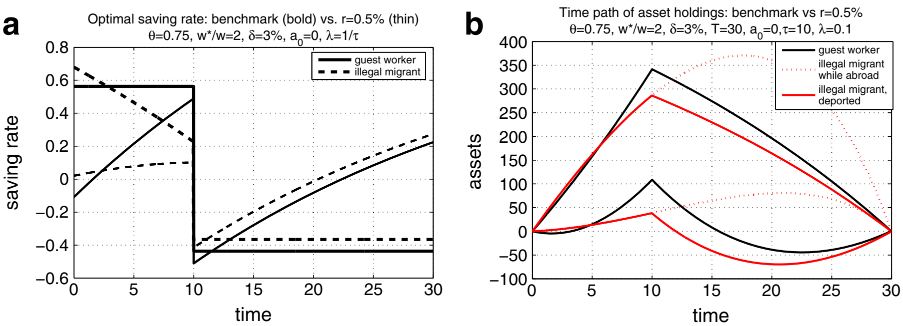
Fig. 9 Optimal paths of savings and asset position, $r = 6\ \%$, $\delta = 3\ \%$

of time preference (benchmark is shown by bold curves). When $r > \delta$, the consumption rate of G follows the Keynes-Ramsey rule growing at $\frac{r-\delta}{\theta} > 0$, and thus the saving rate declines over time, as illustrated in Fig. 9a by the thin solid line. The saving rate of U, shown by the thin dashed line, falls at even higher rate as compared to the benchmark case $r = \delta$ because consumption growth rate is faster (recall Eq. (9)).

When $r < \delta$, the opposite occurs: consumption rates of both U and G decline over time, while the saving rates increase. Relaxing the assumption $r = \delta$ has therefore no bearing on the key results. The precautionary motive remains valid, so as the fact that the saving rate of U ends up being below that of G at the end of their foreign stay. Figures 9b and 10b clearly demonstrate that the total repatriated assets of U (red line) are smaller than those of G (black line) at the time of return.

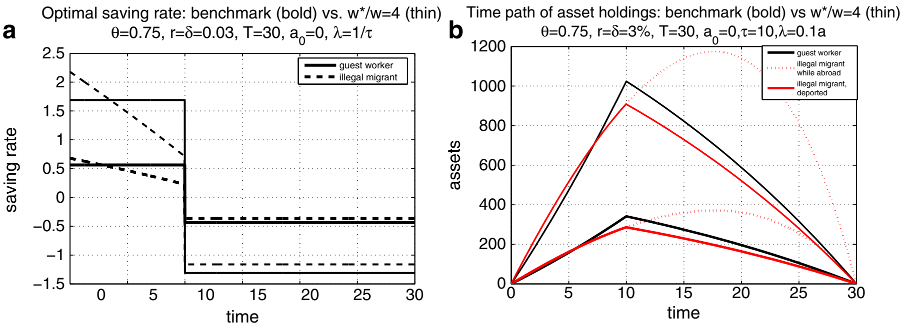
2.4 Wage differential

Figure 11 illustrates the effect of an increase in the wage differential from $w^*/w = 2$ (in the benchmark case, bold lines) to $w^*/w = 4$ (thin lines) on the saving rates and



Saving rate. Time path of assets.

Fig. 10 Optimal paths of savings and asset position, $r = 0.5\ \%$, $\delta = 3\ \%$



Saving rate. Time path of assets.

Fig. 11 Larger wage differential, w^*/w

assets of U and G. Clearly, with a higher wage abroad, the saving rates while in the host country increase, and the dissaving after return is also higher since both migrants have accumulated a larger stock of assets as compared to the benchmark case.

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